Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 415 541 A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 90307957.2

(22) Date of filing: 20.07.90

(51) Int. Cl.5: H01L 31/115, G01T 1/24, H01L 21/60, H01L 31/18

(30) Priority: 29.07.89 JP 197884/89

(43) Date of publication of application: 06.03.91 Bulletin 91/10

(84) Designated Contracting States: DE FR GB

(71) Applicant: SHIMADZU CORPORATION
1 Kuwabara-cho Nishinokyo Nakakyo-ku
Kyoto 604(JP)

(72) Inventor: Sato, Kenji
11-12-313 Tatsugaoka
Otsu-shi(JP)

(74) Representative: Smith, Philip Antony et al
REDDIE & GROSE 16 Theobalds Road
London WC1X 8PL(GB)

(54) **Semiconductor-based radiation image detector and its manufacturing method.**

(57) A semiconductor radiation image detector consists of a semiconductor base (1) having its one surface plated with a common bias electrode (2) and its other surface plated with a plurality of two-dimensionally arrayed pixel-corresponding signal-takeout electrodes (3). The signal takeout electrodes (3) are provided with respective signal lead-out bumps (4). These bumps (4) are connected by a flip-chip joining technique with corresponding pads (6) provided on one side of a separately prepared base plate (5). The signal takeout electrodes (3) are thus free from many intertwining lead wires, making the detector free from problems caused by short-circuits forming across lead wires.

The detector receives a radiation image with the common bias electrode (2) directed to incident radiation rays, resulting in an increase in the image detection efficiency.

In manufacturing this radiation image detector, photoprocessing and metal-plating techniques are used.

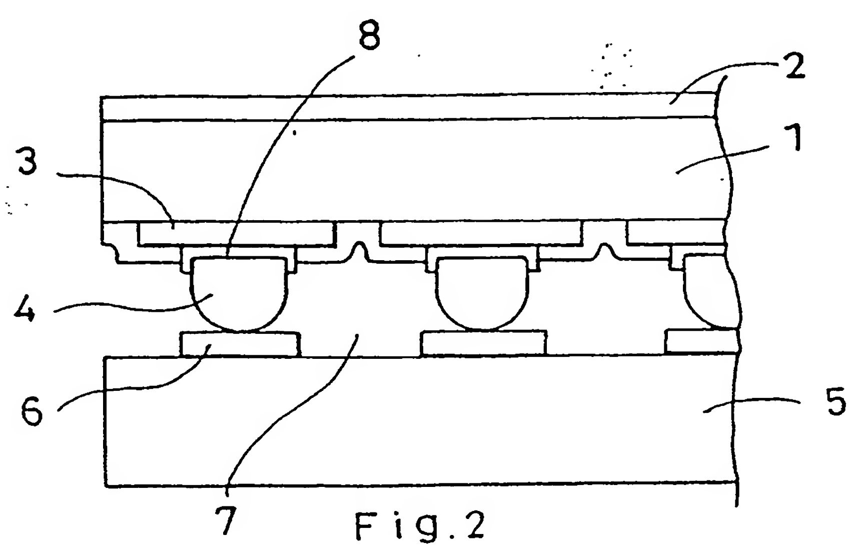

Fig.2

EP 0 415 541 A1

SEMICONDUCTOR-BASED RADIATION IMAGE DETECTOR AND ITS MANUFACTURING METHOD

The present invention relates to a semiconductor-based radiation image detector and its manufacturing method, the detector detecting a radiation image such as that of X-rays with the image divided into pixels

A conventional example of such radiation image detectors consists, as is shown in Figure 5, essentially of a slender radiation-detective semiconductor base 21 having its radiation image receiving front surface provided with one or a few arrays of pixel-corresponding signal takeout electrodes 23 and its back surface plated with a common bias electrode 22. In this manner, arrayed pixel-corresponding unit radiation sensors are formed, each between the common bias electrode 22 and each of the pixel-corresponding signal takeout electrodes 23. The semiconductor base 21 on which are thus formed many pixel-corresponding unit radiation sensors is mounted on a terminal board 25 with the signal takeout electrodes 23 wired by their respective lead wires 24 to terminals 26 printed on the marginal portions of the terminal board 25. The thus constituted one-dimensionally prolonged radiation image detector is made to scan an imaginary plane on which lies an invisible two-dimensional radiation image to be detected.

As is easily understood, such a one-dimensional detector can not instantly detect a two-dimensional image and takes a fairly long time for complete detection of one image because of the scanning operation of the detector. Further, a detector moving mechanism is inevitable. These disadvantages can easily be eliminated or reduced, in principle, by making the detector enlarged two-dimensionally so that it may entirely or partially cover the area of a radiation image to be detected, though in the case of a partially covering detector an image detection operation is necessarily repeated a few times with the detector displaced to complete the detection of one radiation image.

In practice, however, two-dimensional enlargement of the detector is accompanied, as a matter of course, by a tremendous increase in the number of signal takeout electrodes 23, and therefore, of lead wires 24 running crosswise over the signal takeout electrodes 23, often causing the lead wires 24 to be short-circuited. Further, the conventional detector of this type has a disadvantage that the radiation photons falling on the clearances left among the signal takeout electrodes 23 cannot be efficiently converted to electrical signals, because most of the electric carriers Q created by such photons are, as is schematically illustrated in Figure 6, substantially out of carrier acceleration fields developed between the common bias electrode 22 and the signal takeout electrodes 23, and so vanish without contributing to image signals.

An object of the present invention is to provide a large-surfaced two-dimensional radiation image detector by overcoming the above described difficulties involved in two-dimensionally enlarging the conventional radiation image detector consisting of many pixel-corresponding unit radiation sensors.

Another object of the present invention is to make such a two-dimensional radiation image detector capable of making use of all the electric carriers created by the incident photons including those falling on the portions corresponding to the clearances left among the signal takeout electrodes.

A further object of the present invention is to provide a method of manufacturing such a two-dimensional radiation image detector.

An example of the two-dimensional radiation image detector according to the present invention consists essentially of a radiation sensitive semiconductor plate having its one surface provided with a common bias electrode and its other surface provided with a plurality of pixel-corresponding signal takeout electrodes having thereon their respective bumps for leading out electric signals from the signal takeout electrodes. Further, the signal takeout electrodes, with the bumps excluded, and the clearances left among the signal takeout electrodes, are coated with a passivation film. With the radiation image detector having its main part thus constituted, the bumps provided on the signal takeout electrodes are, by means of a flip-chip joining technique, soldered to corresponding pads which are arranged on a separately prepared base plate. The pads are electrically led toward the edges of the base plate by their respective lead circuits printed on the same base plate. Electric image signals outputted from the signal takeout electrodes are thus led out to an external electronic circuit system through the pads and the accompanying printed lead circuits.

According to another example of the detector based on the present invention, the radiation image detector has its main part detachably connected to the base plate.

Any of the radiation image detectors according to the present invention is used with the common bias electrode side directed to incident radiation.

The method of manufacturing the above radiation image detectors, which method also belongs to the present invention, comprises a technique of photoprocessing.

According to the present invention the radiation image detector is advantageously free from a large

number of lead wires running over the signal takeout electrodes. In addition, since a radiation image is received on the common bias electrode side, all of the electric carriers created within a shallow depth of the semiconductor plate are taken out as image signals (refer to Figure 4).

An embodiment of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows an exploded one-point perspective view illustrating the correspondence of a radiation image detector main part to a base plate according to the present invention;

Figure 2 shows a partial side view illustrating the state of cooperation between the radiation image detector main part and the base plate, both shown in Figure' 1;

Figure 3 illustrates stepwise a process of manufacturing the radiation image detector main part shown in Figures 1 and 2;

Figure 4 illustrates the electric carriers created in a radiation image detector according to the present invention;

Figure 5 shows a perspective view of a one-dimensionally prolonged conventional radiation image detector; and

Figure 6 illustrates the elecric carriers created in the conventional radiation image detector shown in Figure 5.

Referring to Figure 1, a radiation image detector as an embodiment of the present invention consists essentially of a radiation sensitive semiconductor plate 1 having its upper surface plated with a common bias electrode 2 and its lower surface plated with a plurality of pixel-corresponding signal takeout electrodes 3 having at their centres their respective bumps 4. Though the lower surface is further coated with a passivation film 7 with the bumps 4 excluded and the bumps 4 are fixed to the electrodes 3 with a gold layer 8 interposed, not all of these are shown in Figure 1. Their details are best shown in Figure 2 to be mentioned later. The radiation image detector is made up of many radiation sensors, each comprising the common bias electrode 1 and a respective pixel-corresponding signal takeout electrode 3, with the semiconductor plate 2 interposed therebetween. With the thus constituted radiation image detector made to cooperate with a separately prepared base plate 5 having on its surface a plurality of pads fixedly arranged corresponding to the signal takeout electrodes 3 of the radiation image detector, all the bumps 4 of the signal takeout electrodes 3 come into contact with the corresponding pads 6, as is shown in Figure 2 which illustrates the cooperating state between the radiation image detector main and the base plate 5. In the figure, reference numerals 7 and 8 respectively indicate the passivation film and the gold layers deposited on the surfaces of the signal takeout electrodes 3.

In the above embodiment the radiation image detector has the bumps 4 made to detachably come into contact with the pads 6, but the present invention can be embodied also with the base plate fixedly combined with the radiation image detector into one body by soldering the bumps 4 to the pads 6. In this case, the bumps 4 themselves are preferably made of solder.

In addition to the above constructional features of the radiation image detectors according to the present invention, any of them is expected to be applied with the common bias electrode side directed to the incident radiation which gives a radiation image to be detected.

According to the present invention, therefore, the radiation image detector not only is free from complicatedly intertwined lead wires which, wired over the signal takeout electrodes, may cause short-circuit troubles, but also has an advantage that all of the dense electric carriers Q generated in a shallow depth just below the common bias plate 2 are substantially fully converted to electric signals, because the electric fields developed between the common bias electrode 2 and the signal takeout electrodes 3, as is easily supposed from Figure 4, show a continuous distribution along the surface of the common bias electrode 2.

In the following, a method of manufacturing such radiation image detectors as mentioned above is described with reference to Figure 3. The method also belongs to the present invention. In Figure 3 is illustrated a series of steps A to J contained in a process of forming the radiation image detector main.

In the first place, a photoresist emulsion is applied to the upper surface of a GaAs, CdTe or the like compound semiconductor plate 1 having its lower surface plated with a common bias electrode 2 of gold, platinum, nickel or aluminium, and then the emulsion is photo-processed so as to leave a photoresist film 11 there except for portions where signal takeout electrodes are to be deposited (step A).

With the remaining photoresist film 11 used as a masking film, nickel is deposited on the semiconductor plate 1 by means of non-electrolytic plating to form signal takeout electrodes 3 (step B). The non-electrolytic nickel plating method can of course be replaced by a nickel evaporating method.

After the signal takeout electrodes, 3 are thus formed, the remaining photoresist film 11 is removed by dissolving it with a suitable solvent (step C).

Next, a photoresist emulsion is again applied covering the signal takeout electrodes 3 and the clearances left among them, and then photo-pro-

cessed so as to leave photoresist films 11a on the signal takeout electrodes 3 and their respective central portions (step D), where signal lead-out bumps are to be finally fixed by means of electroplating.

With bump fixing portions thus preserved, a protective passivation film 7 of silicon oxide or silicon nitride is deposited thereon by evaporation or by an electron cyclotron resonance plasma CVD method, covering the semuconductor plate 1, signal takeout electrodes 3 and their respective photoresist films 11a (step E).

Then, the photoresist films 11a are dissolved with a solvent, and the photoresist films 11a removed to lift off parts of passivation film 7 deposited thereon. Thus the passivation film 7 is left only on the areas except for the central portions of the signal takeout electrodes 3 (step F). These central portions are just the above mentioned bump fixing portions.

With only the bump fixing portions thus made exposed on the signal takeout electrodes 3, a photoresist film 11b is laid only on the remaining passivation films 7 by means of a photo-processing method with their marginal portions excluded, and then as thin a continuous gold layer 8a as possible is deposited thereon by means of evaporation on all the surface of the photoresist film 1lb and the so far exposed (central) portions of the signal takeout electrodes 3 (step G).

With the gold layer 8a thus laid, further a photoresist film 11c is formed thereon except for the bump fixing portions now made recessed due to the surrounding passivation film 7. Then soldering metal is accumulated on the recessed portions by means of electroplating with the gold layer 8a used as an electrode to form there pre-bump solder protrusions 4a (step H).

After the solder protrusions 4a are formed, the photoresist film 11c, the gold layer 8a and the photoresist film 11b are successively removed by means of dissolving the photo resist films and lifting off the gold layer (step I). Since the gold layer 8a is very thin as mentioned above, it can be lifted off relatively easily either by dissolving the photo resist films with a supersonic wave applied or by partially tearing the gold layer 8a mechanically with a photoresist dissolving solvent sprayed.

Finally, after the solder protrusions 4a have been thus exposed, temperature is raised to the melting point of the solder, and the solder protrusions melt to form solder beads as the signal lead-out bumps 4 (step J).

The gold layer 8a employed in the above process can be replaced with any other metal layer, if it is of a metal resistant to electrolytic solution used in the electroplating of solder. For the purpose silver, copper or aluminium also is usable. In addition, the metal layer may be formed as a multilayer made by combining silver, copper or aluminium with nickel, chromium or aluminium.

The radiation image detector main part thus constituted is then combined with a separately prepared base plate 5 (as shown in Figure 2) on which are provided a two-dimensional array of pads 6 corresponding to the signal lead-out bumps 4. In combining both, the bumps 4 of the detector main are solder-joined to the corresponding pads 6 of the base plate 5 by means of a flip-chip joining technique.

As is mentioned previously, an embodiment of the present invention has the detector main part detachably combinable with the base plate, without solder-joining the bumps 4 to the pads 6. In this case, however, it is desirable to constitute the bumps 4 with any other suitable metal that is not as soft as a solder metal, but wear-resistant and somewhat elastic.

Claims

1. A radiation image detector for detecting a radiation image with the image divided into pixels, comprising:
a radiation-sensitive semiconductor plate (1);
a common bias electrode (2) deposited on one surface of the semiconductor plate;
a plurality of pixel-corresponding signal takeout electrodes (3) deposited on the other surface of the semiconductor plate;
a plurality of bumps (4) each of which is fixed on a respective one of the signal takeout electrodes;
a passivation film (7) covering each signal takeout electrode where not in contact with its bump, and covering the clearances between the signal takeout electrodes; and
a base plate (5) on which are provided a plurality of pads (6) corresponding to the bumps.

2. A radiation image detector according to claim 1, characterized in that the bumps are joined to the pads by means of a flip-chip joining technique.

3. A radiation image detector according to claim 1 or claim 2, characterized in that the bumps (4) are made of a solder metal.

4. A radiation image detector according to claims 1, 2 or 3, characterized in that the signal takeout electrodes (3) are of nickel.

5. A method of manufacturing a radiation image detector for detecting a radiation image with' the image divided into pixels, the method comprising:
a first step of plating a semiconductor plate (1) on its one surface with a common bias electrode (2);
a second step of plating said semiconductor plate (1) on its other surface with a plurality of pixel-corresponding signal takeout electrodes (3);

a third step of depositing a passivation film (7) covering the signal takeout electrodes except for a portion of each, and covering clearances left among the signal takeout electrodes;
a fourth step of providing metal protrusions (4a,4) on the uncovered portions of signal takeout electrodes.
6. A method according to claim 5 comprising a fifth step of positioning the metal protrusions in contact with correspondingly arrayed pads (6) fixedly provided on a separately prepared base plate (5).
7. A method of manufacturing a radiation image detector for detecting a radiation image with the image divided into pixels, the method comprising:
a first step of plating a semiconductor plate (1) on its one surface with a common bias electrode (2);
a second step of plating said semiconductor plate (1) on its other surface with a plurality of pixel-corresponding signal takeout electrodes (3) incorporating a process of laying, in advance, a first photoresist film (11) so as to define positions to be plated with the signal takeout electrodes, the first photoresist film being removed after the positions are plated with the signal takeout electrodes;
a third step of laying second photoresist films (11a) respectively on the respective central portions of the signal takeout electrodes by employing a photomasking technique;
a fourth step of depositing a passivation film (7) of silicon oxide covering the signal takeout electrodes, the second photoresist films and clearances left among the signal takeout electrodes;
a fifth step of removing the second photoresist films together with parts of said passivation film deposited on the second photoresist films;
a sixth step of laying, by employing photomasking technique, a third photoresist film (1lb) on parts of the passivation film remaining after the fifth step;
a seventh step of depositing a metal layer (8a) on all the surface formed by the sixth step, the metal layer having recessed portions corresponding to the respective central portions of the signal takeout electrodes;
an eighth step of laying, by employing a photomasking technique, a fourth photoresist film (11c) on the metal layer except for the recessed portions;
a ninth step of providing solder metal protrusions (4a) at the recessed portions by means of electroplating with the metal layer used as an electrode;
a tenth step of removing the fourth and the third photoresist films (11c, 11b) together with parts of the metal layer deposited on the third photoresist film;
an eleventh step of melting the solder protrusions so as to form solder beads (4); and
a twelfth step of soldering, by means of a flip-chip joining technique, the solder beads to pads fixedly provided on a separately prepared base plate, the pads being arrayed corresponding to the solder beads.
8. A method defined in claim 7, characterized in that the metal layer (8a) is of gold.
9. A method defined in claim 7, characterized in that the metal layer (8a) is a multi-layer consisting of gold and nickel.
10. A method defined in claim 5, 6, 7, 8 or 9, characterized in that the signal takeout electrodes (3) are of nickel.

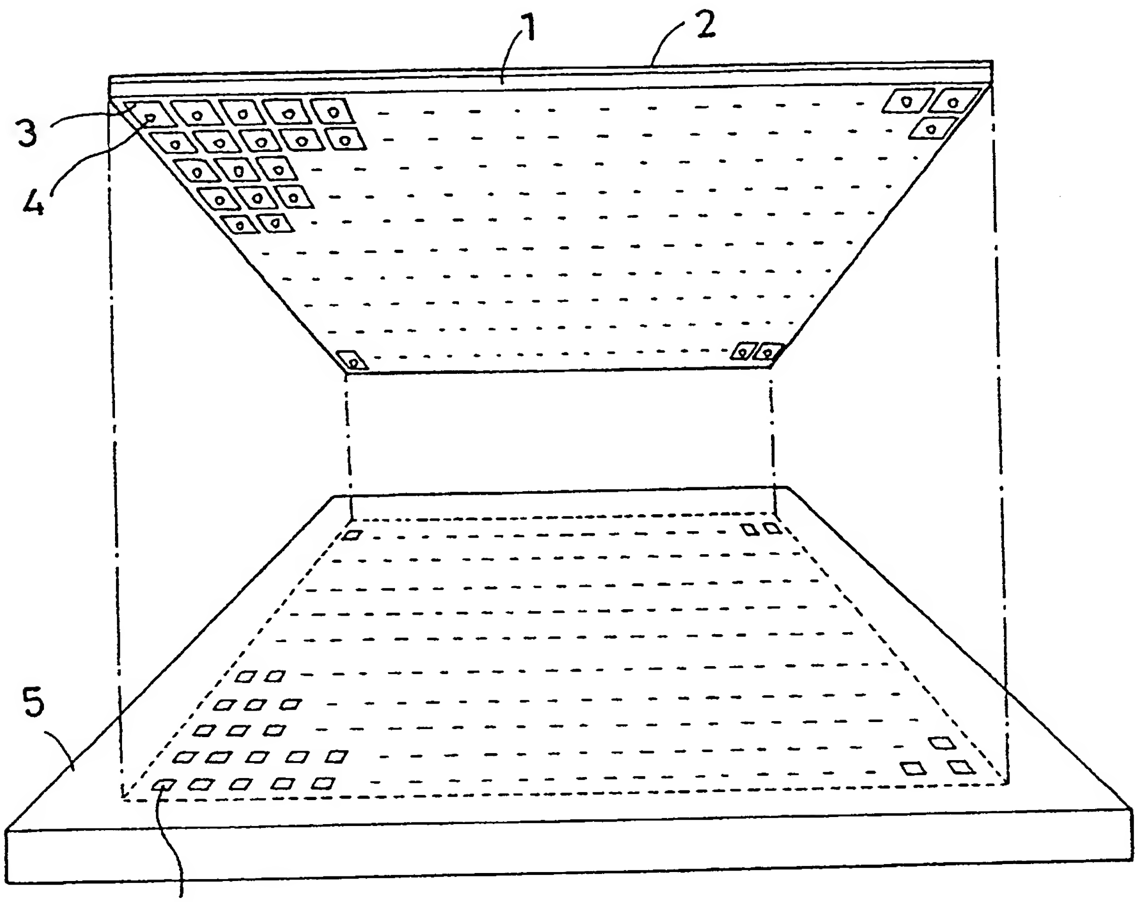

Fig. 1

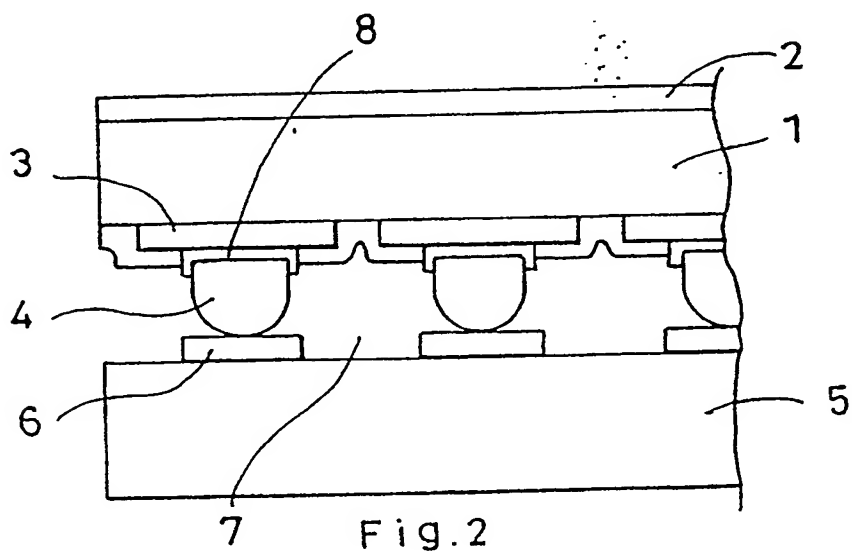

Fig. 2

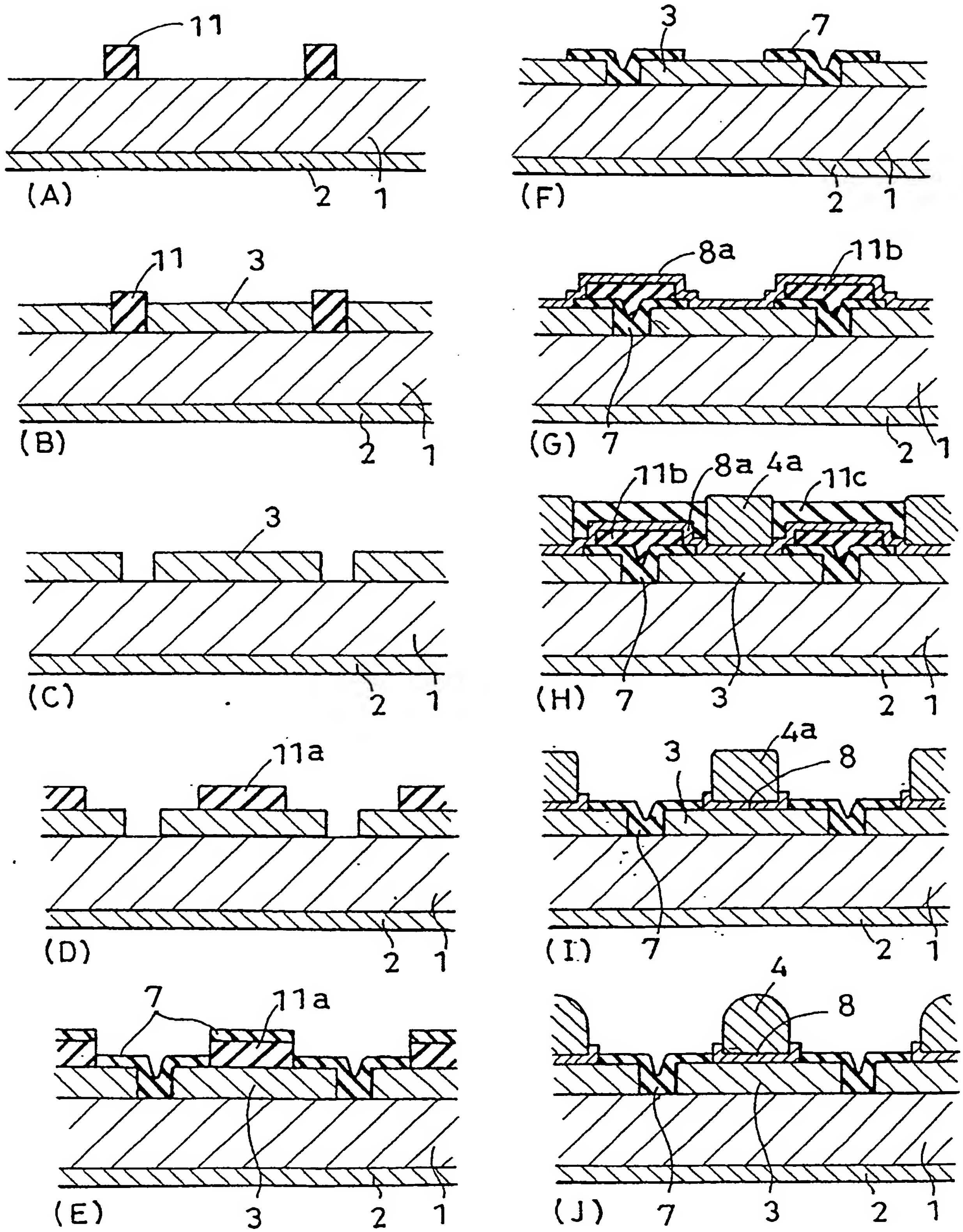
11
(A)
2
1
11
3
(B)
2
1
3
(C)
2
1
11a
(D)
2
1
7
11a
(E)
3
2
1
3
7
(F)
2
1
8a
11b
(G)
7
2
1
11b
8a
4a
11c
(H)
7
3
2
1
4a
3
8
(I)
7
2
1
4
8
(J)
7
3
2
1

Fig. 3

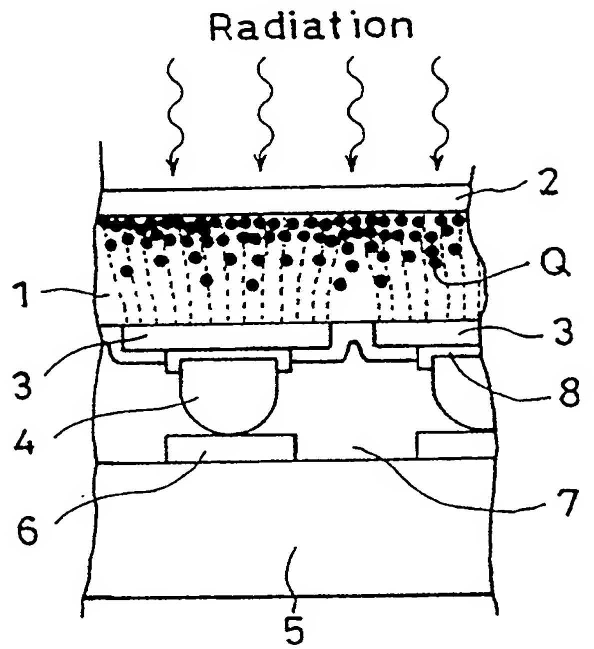

Fig. 4

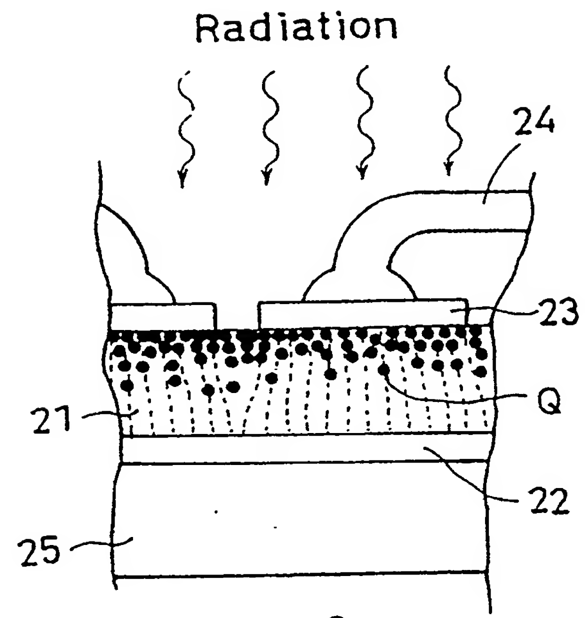

Fig. 6

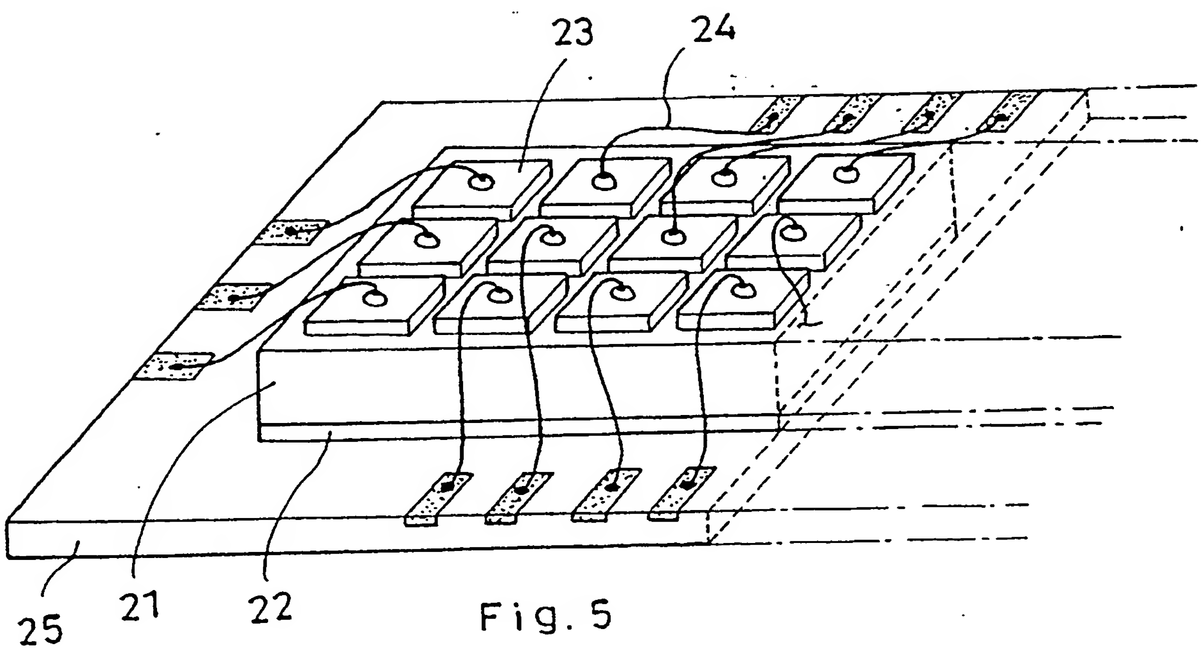

Fig. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 30 7957

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-4 670 653 (C.C.MC CONKLE ET AL.) * column 4, lines 13 - 59; figure 6 * – – –	1-3,5,7	H 01 L 31/115 G 01 T 1/24 H 01 L 21/60 H 01 L 31/18
A	IEEE TRANSACTIONS ON PARTS, HYBRIDS AND PACKAGING. vol. 11, no. 4, December 1975, NEW YORK US pages 312 - 315; D.A.GORSKI ET AL.: "FLIP-CHIP HEADER FOR IR DETECTOR ARRAYS OPERATING AT CRYOGENIC TEMPERATURES" * the whole document * – – –	1-3,5,7	
A	PATENT ABSTRACTS OF JAPAN vol. 9, no. 61 (E-303)(1784) 19 March 1985, & JP-A-59 198769 (FUJI DENKI SEIZO K.K.) 10 November 1984, * the whole document * – – –	1,2,5,7	
A	Proceedings of MELECON'83 Mediterranean Electrotechnical Conference 24 May 1983, ATHENS, GREECE pages 1 - 2; G.GHIONE ET AL.: "COPLANAR LINES IN GaAs HYBRID STRUCTURES : INFLUENCE OF FLIP-CHIP INSERTION" * the whole document * – – –	1-3,5,7	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	5TH IEEE/CHMT INTERNATIONAL ELECTRONIC MANUFACTURING TECHNOLOGY SYMPOSIUM 10 October 1988, LAKE BUENA VISTA, FL, USA pages 23 - 27; K.HATADA ET AL.: "A NEW LSI BONDING TECHNOLOGY "MICRON BUMP BONDING ASSEMBLY TECHNOLOGY"" * the whole document * – – –	1,2,5,7	H 01 L
A	PATENT ABSTRACTS OF JAPAN vol. 11, no. 217 (E-523)(2664) 14 July 1987, & JP-A-62 35634 (HITACHI LTD) 16 February 1987, * the whole document * – – – –/–	1,2,5,7	

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	13 December 90	LINA F.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same catagory
A : technological background
O : non-written disclosure
P : intermediate document
T : theory or principle underlying the invention

E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 30 7957

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-4 661 192 (M.B.MC SHANE) — — — — —		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	13 December 90	LINA F.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same catagory
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: earlier patent document, but published on, or after the filing date
D: document cited in the application
L: document cited for other reasons
&: member of the same patent family, corresponding document